Remarks

Status of the Claims

The Office rejected Claims 1-9, 12-16, and 19-20 under 35 U.S.C. 103(a) as unpatentable over U.S. Patent 6,345,611 (*Hartman*) in view of 4,086,892 (*Marsee*).

The Office objected to Claims 9 and 10 as depending from a rejected base claims, but indicated that they were otherwise allowable.

The Office allowed Claims 17 and 18.

Applicant has amended Claim 14 to depend from allowable Claim 10. Applicant submits that Claim 14 is also in condition for allowance.

Summary of the Invention

The present invention provides a method and apparatus providing for efficient operation of gas engines in non-ideal temperature conditions. The present invention communicates gas from a source to an engine via two reservoirs. Heated exhaust from the engine is routed through a channel that heats the reservoirs, providing heated gas to the engine. In some embodiments of the invention, a pressure regulator is mounted between the source and the first reservoir, such that the pressure regulator accepts unheated gas. In other embodiments, a pressure regulator is mounted between the first and second reservoirs, such that gas is heated in the first reservoir before communication to the pressure regulator. In some embodiments, the two reservoirs comprise cylinders, which, together with a surface or another cylinder, form an exhaust channel.

Summary of the Cited Art

Hartman discloses a heater for gas fuel mounted to a pressure reducing regulator to warm the gas after the temperature is reduced by the pressure reduction, stated as designed to address the problem of gas cooling after pressure reduction. *Hartman's* system includes a pressure regulator and a gas fuel path from the pressure regulator to the engine. A complex path is provided for engine coolant to circulate through *Hartman's* device and warm the gas fuel after the pressure regulator. The engine coolant path is controlled by a wax-based thermostat, allowing the coolant path to be closed whenever the gas is sufficiently warmed.

Marsee discloses a fuel induction system for a liquid-fueled internal combustion engine including a carburetor, a mixing chamber and an intake manifold. Liquid fuel is combined with air in the carburetor, then routed to a box-like mixing chamber, then to the ports of the engine cylinders. *Marsee* discloses that the mixing chamber can be heated by "providing it with a jacket through

which hot engine coolant or exhaust gas circulates." *Marsee* thus provides for heating of a mixing chamber, placed after the carburetor of the engine. *Marsee* has no mention of heating of fuel before it enters the engine, and no mention of pressure regulation of fuel (not surprising since *Marsee* deals exclusively with liquid-fueled engines). *Marsee*, while recognizing that both exhaust gas and engine coolant are hot, has no mention of any design details that would accommodate the difference between coolant (thermostatically controlled to less than 100°C) and exhaust gas (reaching over 450°C, see, e.g., http://www.eng.wayne.edu/page.php?id=753).

Rejections of Claims 1-9, 12-16, and 19-20 on *Hartman* in view of *Marsee*

The Office's rejections are based on *Hartman's* teaching plus several assertions:

> "[I]t would have been obvious ... to modify Hartman et al by employing exhaust gas as the heating medium in lieu of coolant, since these are art recognized equivalents ... as evidenced by Marsee." Office Action page 3.
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> Adding a second cylinder would have been obvious, "since it has been held that mere duplication of essential working parts involves only routine skill in the art," noting that Applicant's Specification stated that "either of the reservoirs R1, R2 can be omitted" thus providing evidence that the device could function with either one or two of the first and second reservoirs." Office Action page 3.
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> "[T]he particular configuration created by the use of two reservoirs would have been an obvious matter of design choice, as the device would function in the same way regardless of the [sic] whether or not an additional reservoir was provided." Office Action page 3.

Applicant respectfully traverses these assertions, as discussed in detail below. Further, Applicant suggests that the Office has neglected several limitations of the Claims, limitations not taught or suggested by *Hartman*, *Marsee*, or their combination.

Use of Exhaust Gas as the Heating Medium

Applicant respectfully traverses the Office's assertion that *Marsee* teaches that engine coolant is recognized in the art as an equivalent, known for the same purpose, as exhaust gas as claimed by Applicant. In order to rely on equivalence as a rationale supporting an obviousness rejection, the equivalency must be recognized in the prior art, and cannot be based on applicant's disclosure or the mere fact that the components at issue are functional or mechanical equivalents. *See, e.g.,* MPEP 2144.06; *In re Ruff*, 256 F.2d 590, 118 USPQ 340 (CCPA 1958).

Further, Applicant's claims recite limitations to an exhaust channel, a limitation not taught or suggested by *Hartman* or *Marsee*.

Applicant readily concedes that exhaust gas and engine coolant are both hot during operation of an engine. However, recognizing that exhaust and coolant are both potential sources of heat does not make them equivalent. Just a few of the differences:

- Exhaust gas heats more quickly after startup than does engine coolant.
- Exhaust gas reaches much higher temperatures that does engine coolant (over 450°C compared to less than 100°C).
- Exhaust gas temperatures are generally unregulated, while engine coolant temperatures are generally thermostatically controlled.
- Exhaust gas is generally ported to outside air, which engine coolant is recirculated under pressure through an engine cooling system.
- Exhaust gas has a large volume relative to its mass (since it's a gas), while engine coolant is relatively more dense (since it's a liquid).
- Exhaust gas has very different heat storage and transfer characteristics than does liquid engine coolant.
- Exhaust gas composition is a function of engine fuel and performance, while engine coolant composition can be tailored for heat storage and transfer.

Because of these and other differences, exhaust gas and engine coolant can not be substituted for each other. Exhaust gas does not have heat transfer and storage characteristics acceptable for use in engine cooling systems – using exhaust gases would rapidly overheat and destroy the engine. Liquid coolant boils at exhaust gas temperatures, destroying its utility as coolant. Liquid coolant encourages rust in exhaust systems. Dry, high temperature exhaust gas would destroy pumps, hoses, and fittings in engine cooling systems.

As a specific example, the substitution of exhaust gas for liquid coolant in *Hartman's* system would destroy both *Hartman's* device and the associated engine. The wax thermostat in *Hartman's* device would melt and boil in the presence of exhaust gas temperatures. Even if the thermostat was not destroyed, closing of the thermostat would shut off exhaust flow, shutting down the engine. *Hartman's* system relies on recirculating the heating medium to the engine; a closed loop engine coolant system is incompatible with the open loop requirements of an engine exhaust system.

Each of the rejected claims includes a limitation to an exhaust channel and the use of exhaust as a heating medium, flowing through the exhaust channel. Exhaust can not be used as a replacement for liquid coolant in *Hartman's* device, and liquid coolant can not be used as a replacement for exhaust gas in Applicant's claimed device. Since exhaust gas and liquid coolant are not equivalents as regards the devices of *Hartman* and Applicant, the art does not teach or suggest all the limitations of the rejected claims. Further, the rejected claims recite specific limitations to exhaust channels; as discussed above, *Hartman's* device does not teach or suggest an exhaust channel, and an attempt to use exhaust gas with *Hartman's* device would destroy *Hartman's* device. Accordingly, there is no *prima facie* case of obviousness based on *Hartman* or the combination of *Hartman* and *Marsee*.

Claim 2 further includes a limitation that the exhaust channel have a second port adapted to allow exhaust to exit the channel. *Hartman* and *Marsee* have no such teaching – *Hartman* requires that the liquid coolant **remain in the engine cooling circulation system** (or the engine will overheat). Accordingly, the art does not teach or suggest this additional limitation of Claim 2, and there is no *prima facie* case of obviousness of Claim 2.

<u>Inclusion of a Second Reservoir</u>

Applicant respectfully traverses the Office's assertion that the addition of a second reservoir is mere duplication of essential working parts. The Office's quotation from Applicant's Specification, if quoted in full, actually teaches that the second cylinder is not mere duplication:

> Note that either of the reservoirs R1, R2 can be omitted; the heat transfer of the system might be reduced, but the resulting single reservoir system will still be advantageous to the operation of the gas engine system. Specification par. [0012], last sentence.

In contrast to the Office's characterization, Applicant's Specification teaches that the second reservoir increases the heat transfer of the system. Specification par. [0012]. Applicant recognizes that a system with a single reservoir can still be useful, but a second reservoir, a limitation in all the rejected claims, is taught by Applicant as critical to increased performance of the system. If the applicant has demonstrated the criticality of a specific limitation, it is not appropriate to rely solely on case law as the rationale to support an obviousness rejection. *See, e.g.,* MPEP 2144.04. The addition of a second reservoir is not mere duplication, and is not taught or suggested in the art. Further, the Office's assertion that "the device would function in the same way regardless of whether or not an additional reservoir was added" is a rejection not based on the invention as a whole – all the limitations must be considered, not just a "gist" or principle of

operation. *See, e.g.*, MPEP 2141.02.II. Accordingly, the art does not teach or suggest all the limitations of the rejected claims, and there is no *prima facie* case of obviousness.

Claims 7 and 19 additionally recite limitations related to pressure regulation between the first and second reservoirs. The first reservoir can thus heat incoming gas **before** it enters the pressure regulator. *Hartman's* teaching exclusively concerns heating gas to compensate for cooling **after** pressure regulation; *Hartman* has no teaching or suggestion of a gas heater on the input side of a pressure regulator. Applicant's Specification teaches that the use of two reservoirs, one on each side of a pressure regulator, can encourage uniform temperature across the regulator and thereby reduce problems arising from uneven temperatures. Specification par. [0015]. *Hartman* teaches heating post-regulation gas, but has no teaching or suggestion of any configuration that encourages uniform input and output gas temperatures. Accordingly, the art does not teach or suggest this additional limitation of Claims 7 and 19, and there is no *prima facie* case of obviousness of Claim 7 and 19.

<u>Particular Configurations Allowed by Two Reservoirs</u>

Applicant is not certain which claims the Office intended to encompass with this assertion. The particular configuration of Claims 7 and 19, with a pressure regulator between the two reservoirs, was discussed above. Claims 12 and 13 recite limitations to specific mechanical configurations. Claim 12 is limited to a configuration where the exhaust channel and both reservoirs are cylinders in physical contact with each other. *See, e.g.*, Figures 4e, 4f .Claim 13 is limited to a configuration where the two reservoirs are cylinders, and an exhaust channel is formed by a surface mounted with the two cylinders. *See, e.g.*, Figure 4c. The specific elements and arrangements of elements claimed in Claims 12 and 13 can offer advantages in ease of fabrication, use of standard parts, simplicity of operation, and compatibility with application requirements. In contrast, *Hartman's* device is much more complicated to fabricate, requires nonstandard components, and relies on assembly of multiple intricate parts (including proper operation of a wax-based thermostat), all of which can be undesirable in applications such as oil field operations. *See, e.g.*, Specification par. [0004]. Accordingly, the art does not teach or suggest all the limitations of Claims 12 and 13, and there is no *prima facie* case of obviousness.